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ABSTRACT

The Institute of Paper Science and Technology (IPST) has developed a process simulation program, MAPPS (Modular Analysis of Pulp and Paper Systems), which calculates material and energy flows and product quality parameters for pulp and paper processes. When integrated with a millwide system, this program can provide process and quality data to operators and managers that can be used for open loop control or as the basis for the development of supervisory and/or advanced control strategies.

An interface has been developed for the IBM Realtime Plant Management System (RPMS) which will facilitate the inclusion of MAPPS as a part of an integrated Millwide Management/Control System. This interface was developed as one of the first "deliverables" from a Chemithermomechanical Pulping (CTMP) Center in which the Institute participates. This paper will present some of the features of MAPPS and discuss its integration with the "millwide" system installed at the CTMP Pilot Plant operated by the Center.

BACKGROUND

Process simulation programs have traditionally been used by researchers and engineers in an "off-line" mode to calculate material and energy flows for continuous industrial processes such as those for the production of pulp and paper. The resulting information was then utilized to design, de-bottleneck, troubleshoot and optimize pulp and paper process systems. With few exceptions, the simulation software resided on mainframe or microcomputers remote from the "real" processes and design data or "averaged" mill data was used to set up the process models.

Although off-line simulation applications serve a valuable function, they often do not include the process operators and their managers, those individuals who could potentially derive direct benefits from the calculated simulation data and information. Also, the inability of conventional simulation programs to link material and energy flows with product quality has reduced the value of using simulation in day-to-day operations since a primary concern of both operators and line managers is the production of a quality product at the lowest cost.

WHAT IS PROCESS SIMULATION?

A process simulation program has been defined as a digital computer program which calculates mass and energy balances for a process (1). Simulators are often classified as either discrete or continuous, steady-state or dynamic, and stochastic or deterministic. In these terms, MAPPS can be described as deterministic, continuous, and steady-state. While it may be argued that a dynamic simulator is more appropriate for a millwide application, the application described in this paper is proof enough that even a steady-state simulator can provide very useful information to an operator or line manager.

MAPPS, like most pulp and paper simulation programs, is a modular simulator. It is comprised of a large number of "modules," each of which is designed to calculate material and energy flows for a particular pulp and paper unit operation. Modules are currently available to simulate every aspect of pulp and paper production, from the wood entering to the product being produced. In addition, MAPPS has the unique capability of calculating both in-process and end-use product quality parameters, a feature called "Performance Attribute Modeling (PAT)." With PATs, a user may configure a process to maximize pulp and paper properties such as tear, burst, tensile, brightness, etc. Alternately, the user may choose to optimize a process configuration to produce, at the lowest cost, a product with specified quality parameters.

To use MAPPS, a flow diagram of the process to be modeled must be converted to a "block" diagram in which the blocks are appropriate MAPPS process modules. The modules are then connected by "streams" which generally represent some physical flow, either material or energy, in the process to be modeled. Actual process operating and/or design data, along with information defining how the simulation model is to be executed, is then written into an "input" file to enable the simulation model to be executed by MAPPS. After execution, all of the calculated material and energy flow data for the process streams, the process parameters, and the quality parameters are stored in an "output" file which the user can access directly or use as an input to other programs, i.e., spreadsheets, databases, etc.

WHAT IS A MILLWIDE SYSTEM?

In the earlier days of millwide development, a millwide system as defined by Fadum was "...the overall integration of production, quality, and cost to optimize the profitability of a mill." More recently, the definition has changed to "...the vertical and horizontal integration of systems and applications to optimize the profitability...etc." In this definition, "vertical" and "horizontal" are defined as the "integration of business and production systems" and "the integration of all process systems," respectively. Fadum has also defined application integration as the ability of software packages to work together, i.e., accounting/purchasing, maintenance/stores, etc. Thus, it follows that a mill moves toward millwide by tying systems and applications together and achieves millwide when all systems and applications are tied together (2).

Couched in terms of hardware and software, a simple millwide system can consist of one or more distributed control systems (DCS) for primary process control tied to a management information system that may include both business and production applications. In more advanced millwide networks, higher level systems, i.e., above the DCS level, may also be in place for supervisory or advanced control applications.

Millwide, in addition to encompassing the DCS for field control of pulp and paper processes, must also include systems to provide timely and accurate process and control data to the operators and managers. Such process and control data can then be used for open loop control by operators/managers or for closed loop control via supervisory/advanced systems. It is within this context that process simulation applications have a place in millwide systems.

CAN PROCESS SIMULATION BE A TOOL FOR THE OPERATOR?

Although this paper is concerned with the application of simulation, it must be remembered that a simulator is only another "tool" that one can use to obtain more timely and accurate data and information about a process. As with any tool, even a shovel, there is a learning curve associated with its use. A major limitation to the development of process simulation applications has been the willingness and/or ability of the potential user to overcome "the learning curve." Much development effort, though many users would say "not enough," has gone into the creation of "user-friendly" interfaces for process simulation programs.

Beyond the pros and cons of learning curves and user-friendly interfaces, however, a successful simulation user must be a visionary. To paraphrase a familiar expression, "What does it profit a man to simulate if he doesn't know what to do with the data." Using a more physical parallel, one could say, "If you have only one leg, don't bother to buy a shovel." In other words, before expending the resources required to buy and learn to use a new tool, you must first decide whether you need it and, if so, can you use it to improve your performance.

As noted earlier, the typical process simulation user has been an engineer or scientist. With a technical background and an inclination to use computer-based tools, these individuals have been more likely to recognize the need for the tool and thus make the effort to acquire and use it. Yet, it can arguably be stated that the greatest potential for the utilization of simulation has yet to be tapped, i.e., in the on-line mode as a part of a millwide system.

Simulation models for millwide systems, however, require some additional consideration during configuration. For instance, given the demands on the process operators and managers, the model should be transparent to the user and only the calculated simulation data that is pertinent and useful to the operator and/or manager should be presented on system graphic displays. The CTMP Pilot Plant application discussed below has these characteristics.

DEMONSTRATION OF A MILLWIDE APPLICATION

IPST is a participating member in a CTMP Center formed to promote research in high-yield mechanical pulping. The Center operates a CTMP Pilot Plant, donated by Mead Corporation, which is comprised of a two-stage Sunds Defibrator refining system with chemical pretreatment and interstage washing units. The process system is controlled by a Taylor MOD 300 DCS donated by ABB Process Automation and, in turn, the DCS is interfaced with a Realtime Plant Management System (RPMS) donated by IBM Corporation. MAPPS runs as a slave program under the RPMS and can read process data inputs from the RPMS database and write calculated process data and pulp quality data back to the database (Figure 1).

Configuration of the Modeling System

To facilitate the transfer of process measurement data and data calculated by MAPPS, the RPMS database and the associated screen graphic displays were configured using the tag naming convention of the Mod 300 control configuration. Thus, as process data from the DCS is written to the RPMS database, any measured data inputs required by MAPPS can be accessed via the RPMS/MAPPS interface. This is accomplished by referencing the DCS tag name as a part of the MAPPS input data file. Similarly, selected calculated material and energy flows and quality parameters are given a unique tag name in the MAPPS output and are written back to the RPMS database as MAPPS is executed. The calculated data can then be used for open loop control or alternately used to develop supervisory/advanced control schemes for closed loop control. The measured data from process sensors and the data calculated by MAPPS are displayed, via RPMS routines, on the graphical screens configured for the RPMS operator stations.

A "flat file" containing the command structure to read the MAPPS input data file, run the model, and store the predicted results was set up to run as a slave program within RPMS. As is typical for most simulation programs, much of the input data required to run the MAPPS simulation is independent of the process design or measured data, i.e., key words, system commands, topological information, etc. Process information, via the RPMS database, is read into the MAPPS input file by typing the MOD 300 and/or the RPMS tag name at the appropriate location. Then, when the MAPPS executive reads the input data file, the tag names are parsed as input data and the current tag values from the RPMS database are read into the file. After MAPPS is executed, a similar tag name procedure is used to write the important calculated data back to the RPMS database.

The CTMP Pilot Plant MAPPS Model

Using the PAT Modeling feature of MAPPS, a very detailed process model of the CTMP Pilot Plant was developed to calculate the mass and energy flows and pulp quality parameters of the Pilot Plant process streams. The model features newly developed modules to predict the mass transport and chemical reaction kinetics of the chemical pretreatment steps in the process and existing modules to describe the chip and pulp refiners. In addition, modules were also included to model other energy consuming devices, such as chip and pulp screw feeders and conveyors.

When MAPPS is executed, very detailed information, such as total flowrate, fiber fraction (denoted as fiber length and width distribution) flowrates, other suspended or dissolved component flowrates, temperature, pressures, other thermodynamic properties, and performance attribute data (quality data) about each process stream is stored in a MAPPS output file. Any or all of this information can be presented at the operator's RPMS workstation, either as part of a process graphic display or in tabular or graphical form. Examples of such displays, obtained by photographing actual RPMS screen displays, are illustrated in the brief process description which follows.

The CTMP Pilot Plant process is depicted in the RPMS overview screen graphic (Figure 2). Chips are conveyed by a screw feeder to the first pretreatment stage where they are impregnated with a water solution of EDTA or DTPA. After excess water is "squeezed" out by screw feeders, the chips are impregnated with a mild alkaline liquor such as sodium sulfite or hydrogen peroxide in a second impregnation stage. After being preheated in a small digester, the chips are conveyed to the first refining stage which can be operated under pressure or atmospheric conditions. The pulp from the first-stage refiner can then be conveyed via an interstage washer to a second stage of atmospheric refining, or it can be blown directly to the second refiner via a cyclone.

Figure 3 shows a screen graphic display of the second stage of refining (raffinator). Both measured variables and calculated variables are displayed, differentiated by their colors, on the screen. Generally, measured variables are temperatures and a few flowrates, with the remaining variables coming from the MAPPS simulation via the RPMS database. Note that when the screen was configured, a data table was also included to present some of the important measured and calculated variables to the operator.

To present the pulp quality data, a screen of tabular data was configured (Figure 4). In addition to the name and calculated quality value, a tag name indicating the location of the data in the RPMS database was included. Quality data can also be presented in a graphical format, as shown by Figure 5, where the fiber length distribution of the pulp from the second refining stage is presented.

Although space limitations preclude the inclusion of all of the RPMS screen displays associated with the simulation model, those discussed above are indicative of the types of displays used in the configuration. Generally, by touching the screen or predefined keys, the operator can easily access process and energy flows and quality-related data calculated by the MAPPS model of the CTMP Pilot Plant.

CONCLUSION

A MAPPS simulation model of a pulp and paper process can be a very useful addition to a millwide system. The demonstration model of the CTMP Pilot Plant illustrates how simulation data can be provided to an operator and, as a part of a higher level supervisory system such as the RPMS, made available for open or closed loop control schemes. IPST will continue to work with this model and other applications to facilitate the movement of simulation from the desktop to the millsite. We invite your interest and participation!

REFERENCES

1. "Introduction to Process Simulation," Robert R. McConnell, Editor, TAPPI Press, Atlanta, Georgia, 1985.

2. Personal Communication with Ole C. Fadum, June 26, 1990.

Pilot System Integration

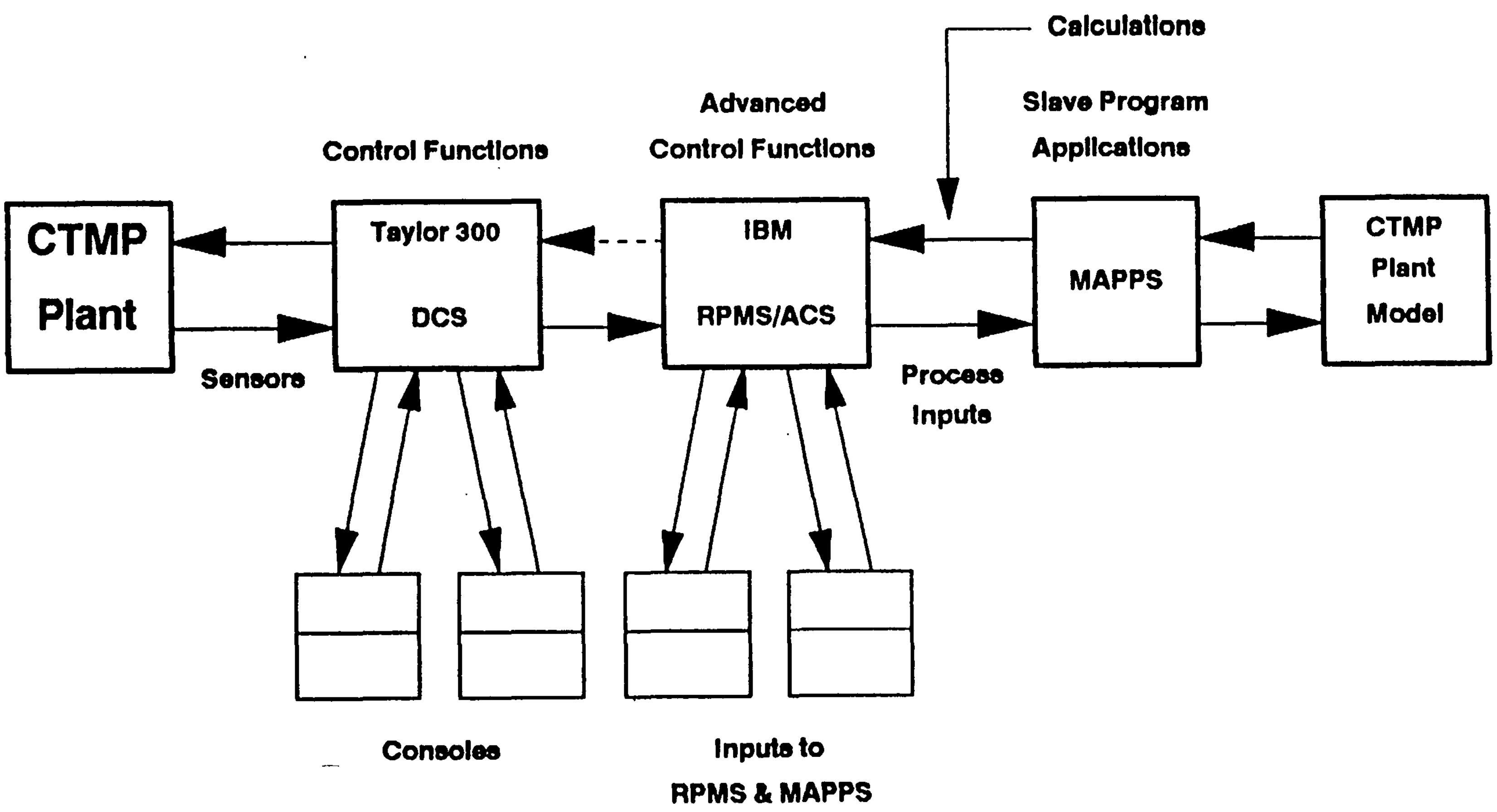


Figure 1

FIGURE 2

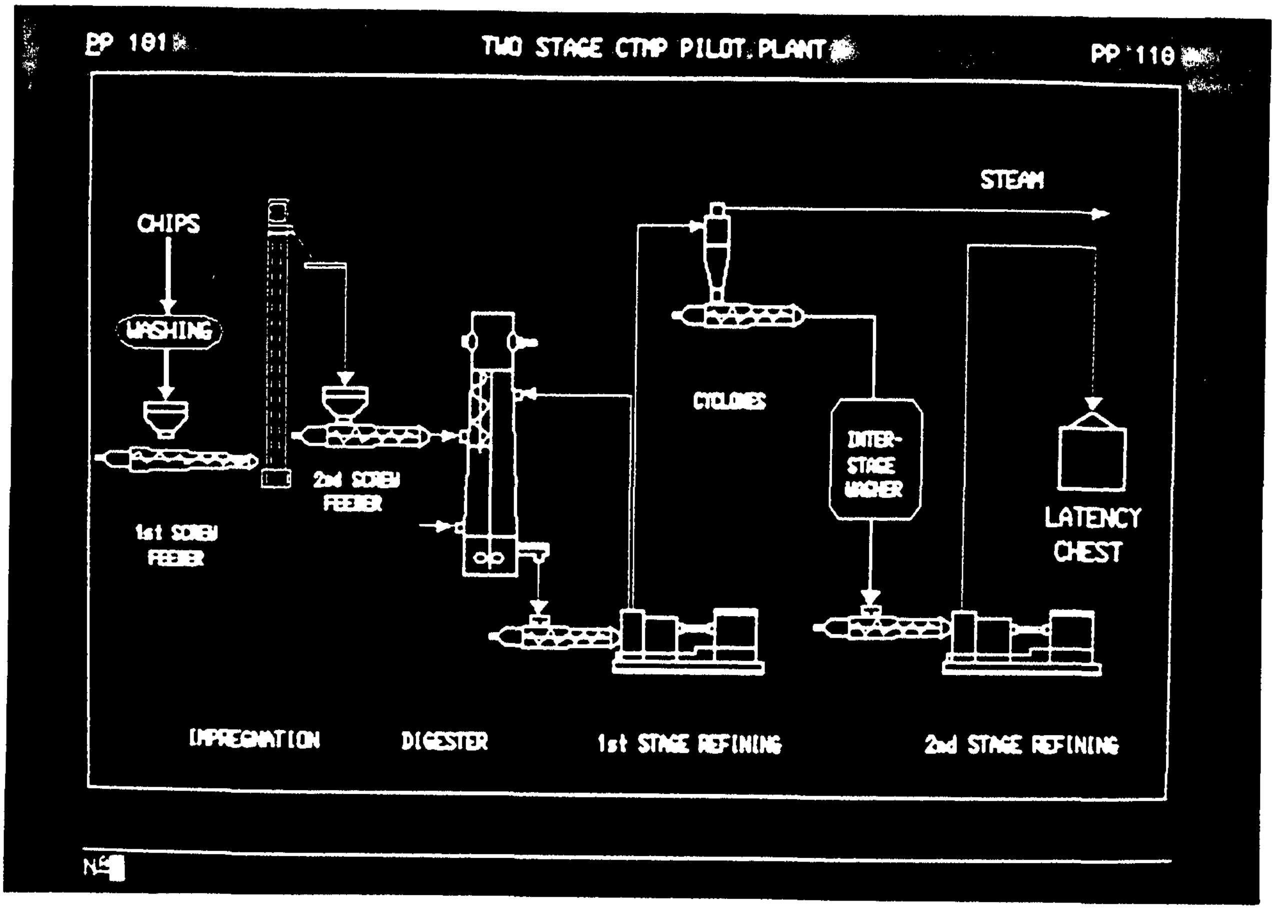


FIGURE 3

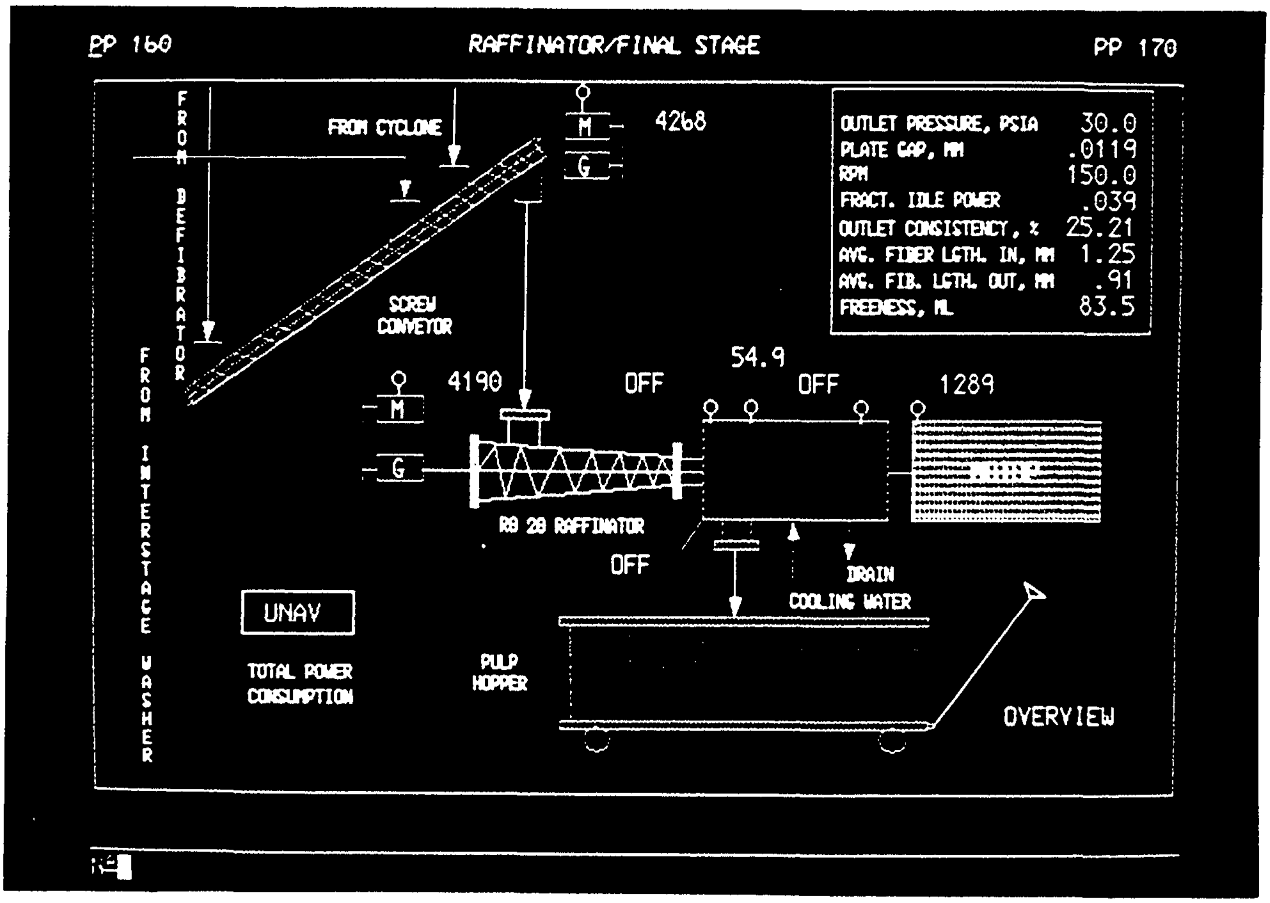
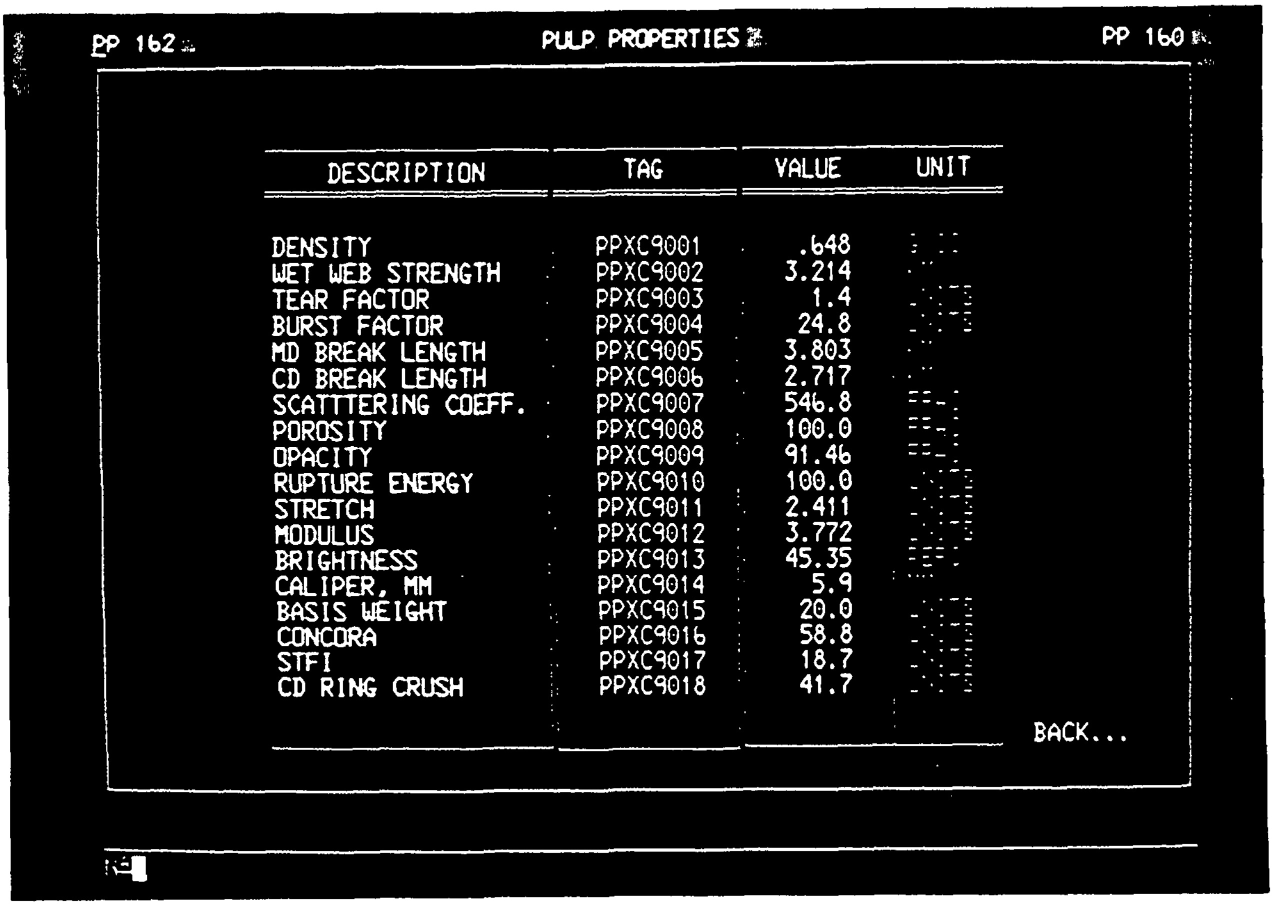


FIGURE 4



PP 162 PULP PROPERTIES PP 160

DESCRIPTION	TAG	VALUE	UNIT
DENSITY	PPXC9001	.648	
WET WEB STRENGTH	PPXC9002	3.214	
TEAR FACTOR	PPXC9003	1.4	
BURST FACTOR	PPXC9004	24.8	
MD BREAK LENGTH	PPXC9005	3.803	
CD BREAK LENGTH	PPXC9006	2.717	
SCATTTERING COEFF.	PPXC9007	546.8	
POROSITY	PPXC9008	100.0	
OPACITY	PPXC9009	91.46	
RUPTURE ENERGY	PPXC9010	100.0	
STRETCH	PPXC9011	2.411	
MODULUS	PPXC9012	3.772	
BRIGHTNESS	PPXC9013	45.35	
CALIPER, MM	PPXC9014	5.9	
BASIS WEIGHT	PPXC9015	20.0	
CONCORA	PPXC9016	58.8	
STFI	PPXC9017	18.7	
CD RING CRUSH	PPXC9018	41.7	

BACK...

FIGURE 5